

Claims 6-10 are directed to a chamber cleaning method and cleaning gas in which a plasma CVD chamber is treated under chamber cleaning conditions with at least one chamber cleaning gas comprising hexafluoropropylene. Novelty of the claimed invention lies, in part, by treating a plasma CVD chamber with hexafluoropropylene under chamber cleaning conditions well known in the art.

In a non-limiting example for exemplary purposes only, chamber cleaning conditions may include a pressure of 100 m Torr, input high-frequency power of 300 watts, a gas flow rate of 50 cc/min. and a duration of 30 minutes as provided in the specification on page 3, lines 11-14. Using the aforementioned conditions, the hexafluoropropylene of the claimed invention fully and quickly removes attached by-products from the chamber without damaging the chamber (see specification, page 3, line 14 - page 4, line 4). While the specification discloses the aforementioned chamber cleaning conditions, one of ordinary skill may adapt alternative chamber cleaning conditions known in the art as necessary to achieve a desired cleaning result.

Contrary to the Examiner's assertion, Sony does not anticipate the present invention as claimed. Although the Examiner alleges that Sony teaches the claimed method of treating a CVD chamber, Sony is completely silent with regard to a plasma CVD chamber.

Furthermore, contrary to the CVD chamber cleaning method of the present invention, Sony is directed to an etching method of a semiconductor substrate (Sony, Abstract). Sony fails to teach or suggest a method for cleaning a CVD chamber. Therefore claims 6 and 7 are not anticipated by Sony. Applicant respectfully requests that the Examiner withdraw the rejection to claims 6 and 7 as being anticipated by Sony.

Further, contrary to the Examiner's assertion, claims 6-10 are not obvious from Gabric in view of Sony. The individual and, arguendo, combined teaching of Gabric and Sony fail to teach or suggest a CVD chamber cleaning method in which a hexafluoropropylene gas is used under chamber cleaning conditions, as claimed.

Gabric's cleaning method has a step of adding an ozone/oxygen mixture having optimally high ozone concentration to an etching mixture. In Gabric's cleaning gas, ozone/oxygen is a crucial component for cleaning (col. 3, line 47 – col. 4, line 10). Gabric fails to teach that fluoridated carbon, as such, could work as a cleaning gas.

According, even though Sony discloses the use of  $\text{CF}_3\text{CFCF}_2$  unsaturated gas as an etching gas, it would not have been obvious that  $\text{CF}_3\text{CFCF}_2$  unsaturated gas could work as a cleaning gas without an ozone/oxygen mixture taught by Gabric. It would not be obvious to combine an etching method with a cleaning method since etching and cleaning methods are considered complete different procedures and are not generally conducted in the same manner.

To further illustrate the differences between the prior art and the claimed invention, reference is made to Figs. A-C, attached herewith. Fig. A shows an example of an etching device, and Figs. B and C show examples of cleaning devices.

The Examiner mentioned that the disassociation of molecules into respective ionic species is itself a "chemical" reaction (Office Action, ¶ 6). But a disassociation of molecules into respective ionic species in a plasma is caused mainly by a collision between a molecule and an electron with high energy. Accordingly it would be more appropriate to call the disassociation "a physical reaction/phenomenon".

The Examiner also mentioned that the energy to activate the etching gas is continuously applied to the electrodes in the chamber until the desired results are

obtained with the etching/cleaning plasma gas. It is respectfully noted that an etching species in cleaning is mainly fluorine free radical, which is neutral and not given any energy from an electric field induced by the radio frequency power applied to the electrodes. Therefore it would be more appropriate to say that the electric field accelerates electrons in the plasma, which collide with molecules/radicals to form fluorine free radicals, or etching species in cleaning.

The Examiner also mentioned that energy is supplied to the ions in the plasma gas. However, it is respectfully noted that ions in a plasma are not supplied enough energy to move around for etching or cleaning. This is also seen from the fact that in etching, a blocking condenser (blocking capacitor) is required to store charge and to create bias voltage (see attached Fig. A). This bias voltage gives ions energy to hit a biased substrate for etching. On the other hand, a bias voltage is not required in cleaning (see attached Figs. B and C).

The Examiner mentioned that both cations and fluorine free radicals are present in the CVD chamber, both etching and plasma cleaning take place at the same time (Office Action, ¶ 7). Applicant respectfully disagrees with the Examiner's assertion as explained below.

The Examiner alleges that etching and cleaning processes take place simultaneously in the chamber under plasma conditions. Applicant respectfully refutes this allegation because under Sony's ion-assisted etching conditions, a cleaning by ions would hardly happen. The reason is explained as follows:

a plasma potential is around 20 V, a ground potential (a potential of chamber walls) is 0 V, and a floating potential is around 5 V (in case that there are some insulative deposits, such as  $\text{SiO}_2$ , on the chamber walls)

(see Fig. A). The potential difference is around 15 V to 20 V, which leads ions attracted to the chamber walls. If  $\text{SiO}_2$  has deposited on the walls,  $\text{SiO}_2$  would be etched a little bit. But in a potential difference of only 15 to 20 V, an ion-assisted etching would be unlikely to happen, because a deposition of fluorocarbon via radicals would surpass etching.

In Example 1 of Sony, a magnetron type RIE (reactive ion etching) equipment is used for etching, which means that a substrate to be etched is put on an electrode set in an etching chamber.

A mechanism of an etching in a RIE equipment is generally as follows: plasma is formed by applying radio frequency power through a blocking condenser on one of two electrodes which are parallel to each other in a vacuum chamber, the other electrode being earthed, wherein the surface of the power-applied electrode is direct-current-biased to create more than several hundred volt of a self-bias voltage, resulting in positive ions, being accelerated by the voltage in the plasma, and directly enter a wafer, to conduct an isotropic etching.

A magnetron type RIE equipment is further equipped with a magnetic field perpendicular to an electric field to enhance a collision rate of an electron and a neutral atom/a molecule.

Applying a big negative electric potential to a substrate to be etched causes a big potential difference between plasma potential and the substrate's potential so as to accelerate etching ions to a surface of the substrate in order to etch the substrate.

In order to conduct an ion-assisted etching efficiently, fluorocarbon radicals need to be deposited on  $\text{SiO}_2$ . After deposition of fluorocarbon radicals on  $\text{SiO}_2$ , a reactive

layer such as  $\text{SiO}_x\text{C}_y\text{F}_z$  is formed between  $\text{SiO}_2$  layer and fluorocarbon layer by high-energy incident ions. Then  $\text{CO}$ ,  $\text{CO}_2$ ,  $\text{COF}_2$ ,  $\text{SiF}_4$ , and the like are emitted from the reactive layer.

The fluorocarbon layer works as a protective layer against fluorine free radicals, since etching by fluorine free radicals is isotropic, which is not preferable in an ion-assisted etching which requires an etching selectivity.

In contrast to an etching process, a cleaning process proceeds by a chemical etching, that is, a chemical reaction of fluorine free radical with  $\text{SiO}_2$  or  $\text{SiN}$  to produce volatile  $\text{SiF}_4$ . As mentioned above, the chemical etching by fluorine free radical is isotropic.

Fluorine free radicals are the main reactive species in cleaning, and ions do not need to be given any energy from a potential difference, so that a bias voltage is not required as discussed above and that electrodes are used only to discharge electricity to form a plasma.

The conditions in etching are set to form fluorocarbon free radicals or ions and to avoid forming fluorine free radicals as much as possible, and the conditions in cleaning are set to form fluorine free radicals as much as possible. Although these conditions can be changed depending on a chamber size, a chamber pressure, electrode spacing, an electrode size, power, RF frequency and so forth, a main point is that an electron temperature should be low in etching and be high in cleaning. When an electron temperature is high, fluorine free radicals increase, which is appropriate for cleaning, not for an etching.

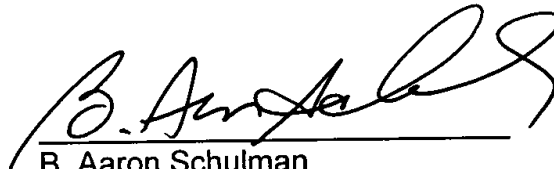
Based on the foregoing, Applicant respectfully submits that the claimed invention is novel and non-obvious over Sony in view of Gabric since the cited art fails to make obvious a method for cleaning a plasma CVD chamber with hexafluoropropylene using chamber cleaning conditions as claimed.

Applicant thus submits that the present application is now in condition for immediate allowance, and such action is earnestly solicited.

Respectfully submitted,

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## ATTACHMENT A

### Clean Replacement Claim

Following herewith is a clean copy of each claim which replaces each previous claim having the same number.

6. (Amended) A chamber cleaning method comprising:

DL treating a plasma CVD chamber of a semiconductor integrated circuit production device under chamber cleaning conditions with at least one chamber cleaning gas

selected from the group consisting of  $\text{CF}_3\text{CF}=\text{CF}_2$ ,  $\text{CF}_3\text{CF}-\text{CF}_2$  and  $\text{CF}_3\text{C}=\text{O}$  thereby removing by products formed on the chamber during CVD processing.

10. (Amended) A chamber cleaning gas mixture comprising a gas selected from the

group consisting of  $\text{CF}_3\text{CF}=\text{CF}_2$ ,  $\text{CF}_3\text{CF}-\text{CF}_2$  and  $\text{CF}_3\text{C}=\text{O}$  and at least one monomer gas selected from the group consisting of He, Ne, Ar,  $\text{H}_2$ ,  $\text{N}_2$  and  $\text{O}_2$ .

## ATTACHMENT B

### Marked Up Replacement Claim

Following herewith is a marked up copy of each rewritten claim.

6. (Amended) A chamber cleaning method comprising: ~~the step of~~  
treating a plasma CVD chamber of a semiconductor integrated circuit production  
device under chamber cleaning conditions with at least one chamber cleaning gas

selected from the group consisting of  $\text{CF}_3\text{CF}=\text{CF}_2$ ,  $\begin{array}{c} \text{CF}_3 \quad \text{CF}-\text{CF}_2 \\ \quad \quad \quad \diagdown \quad \diagup \\ \quad \quad \quad \text{O} \end{array}$  and  $\begin{array}{c} \text{CF}_3 \text{C}=\text{O} \\ | \\ \text{CF}_3 \end{array}$  thereby  
removing by products formed on the chamber during CVD processing.

10. (Amended) A chamber cleaning gas mixture comprising according to claim 6  
which further comprises a gas selected from the group consisting of  $\text{CF}_3\text{CF}=\text{CF}_2$ ,

$\begin{array}{c} \text{CF}_3 \quad \text{CF}-\text{CF}_2 \\ \quad \quad \quad \diagdown \quad \diagup \\ \quad \quad \quad \text{O} \end{array}$  and  $\begin{array}{c} \text{CF}_3 \text{C}=\text{O} \\ | \\ \text{CF}_3 \end{array}$  and at least one monomer gas selected from the group  
consisting of He, Ne, Ar, H<sub>2</sub>, N<sub>2</sub> and O<sub>2</sub>.



# Dry Etch(self-bias)

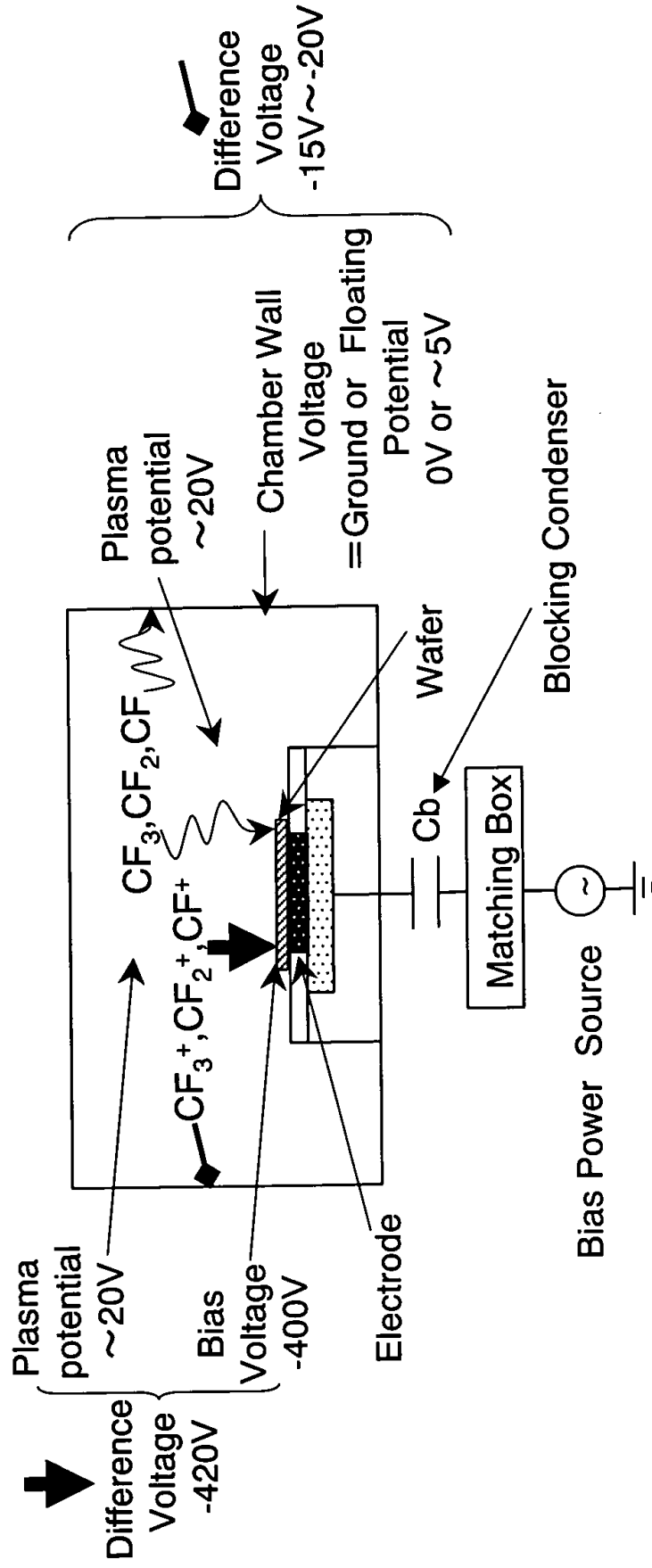


Fig. A

# CVD Chamber Cleaning 1 (Direct Type)

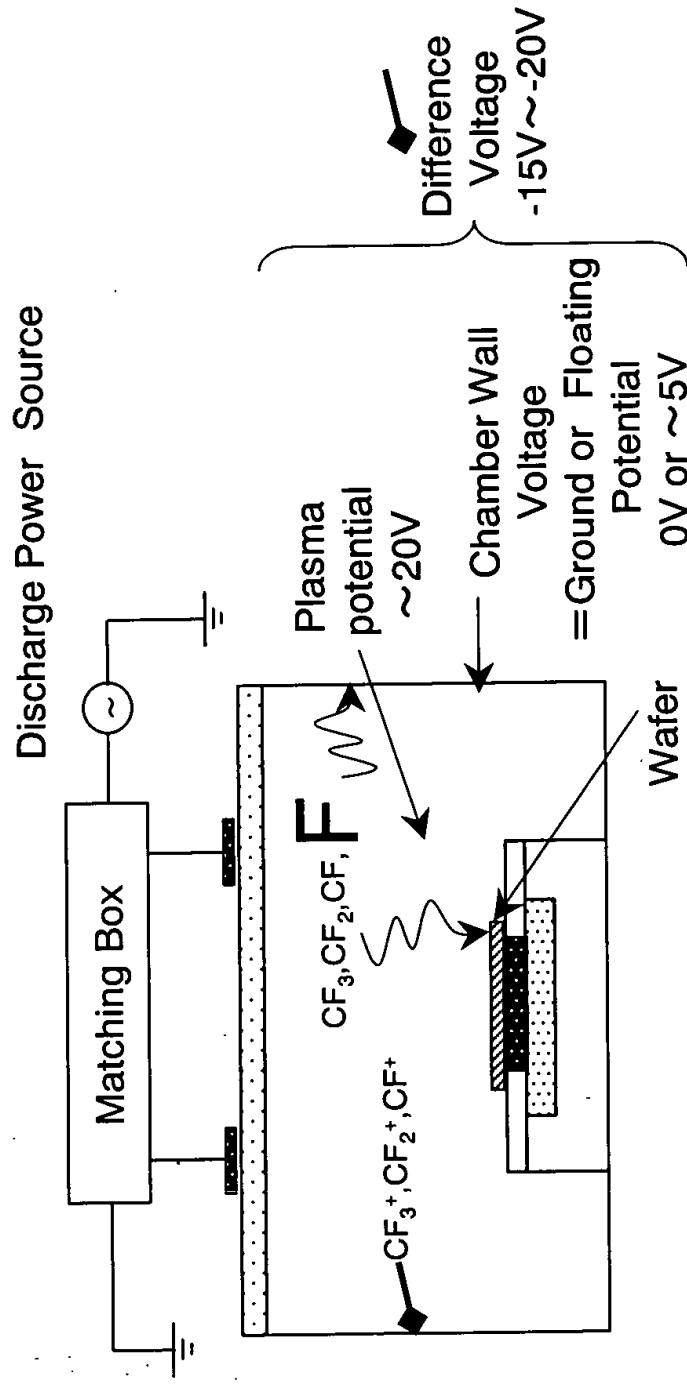


Fig. B

# CVD Chamber Cleaning 2 (Down Flow Type)

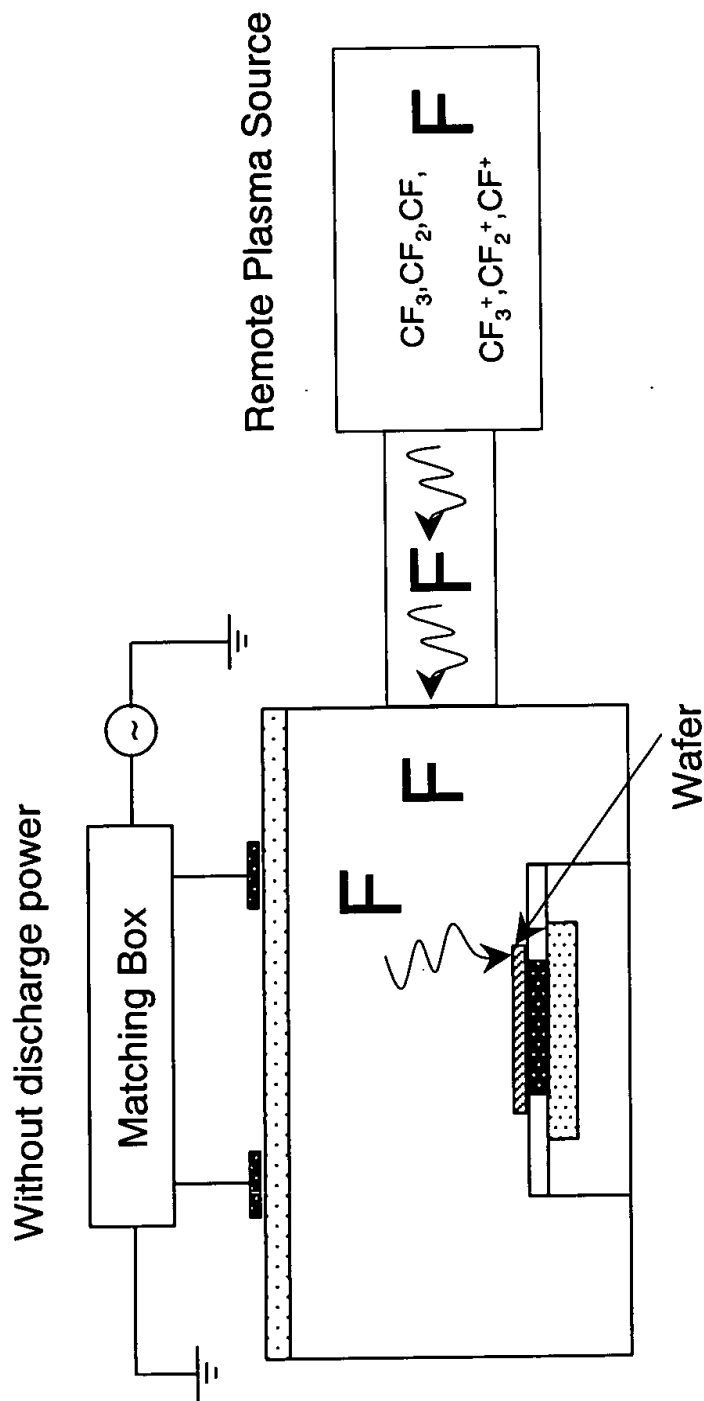


Fig. C

